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Heil, Jr. et al.

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[54] METHOD AND APPARATUS FOR PRODUCING FASTENERS HAVING WRENCHING SOCKETS THEREIN

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[73] Assignee: The National Machinery Company, Tiffin, Ohio

[21] Appl. No.: 135,610

[22] Filed: Dec. 21, 1987

[51] Int. Cl.[4] B21D 37/08; B21K 1/44

[52] U.S. Cl. .... 72/356; 72/359; 10/27 E; 10/27 H; 10/27 PH

[58] Field of Search .... 72/352, 353, 356, 358, 72/359; 10/27 E, 27 H, 27 PH, 27 R

[56] References Cited

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1,051,088	1/1913	Clark	10/27 PH
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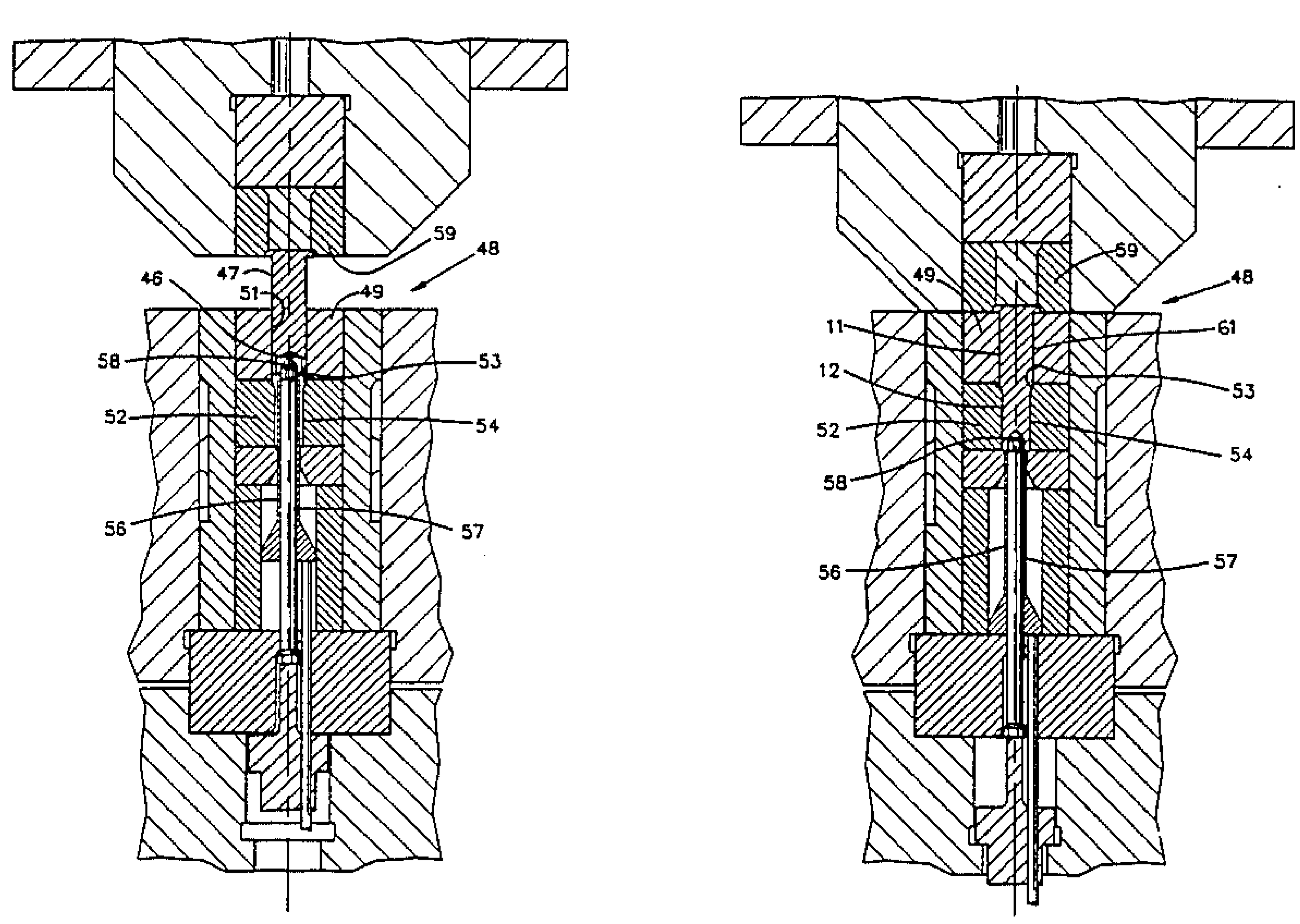
Primary Examiner—Lowell A. Larson

Attorney, Agent, or Firm—Pearne, Gordon, McCoy & Granger

[57] ABSTRACT

A method and apparatus are disclosed for forging a wrenching socket in the end of a fastener which permit the production of such fasteners from materials which are difficult to forge, such as titanium and some high strength steels. A cylindrical preliminary socket is formed in the end of the blank forming the fastener with a punch having a circular cross section. The preliminary socket is sized to be at least as great as the maximum lateral dimension of the finished wrenching socket required. Subsequently, a tool having a cross-sectional shape corresponding to the required finished socket is positioned in the preliminary socket and the material of the blank is extruded inwardly against the tool to form a cylindrical exterior surface and a finished socket having a non-circular cross section. With this invention, even very small hexagonal sockets can be formed in titanium fasteners. The particular illustrated embodiment also utilizes warm-forming, in which the blank material is heated to a temperature in the range of 1200° to 1400° F. before being formed.

17 Claims, 3 Drawing Sheets



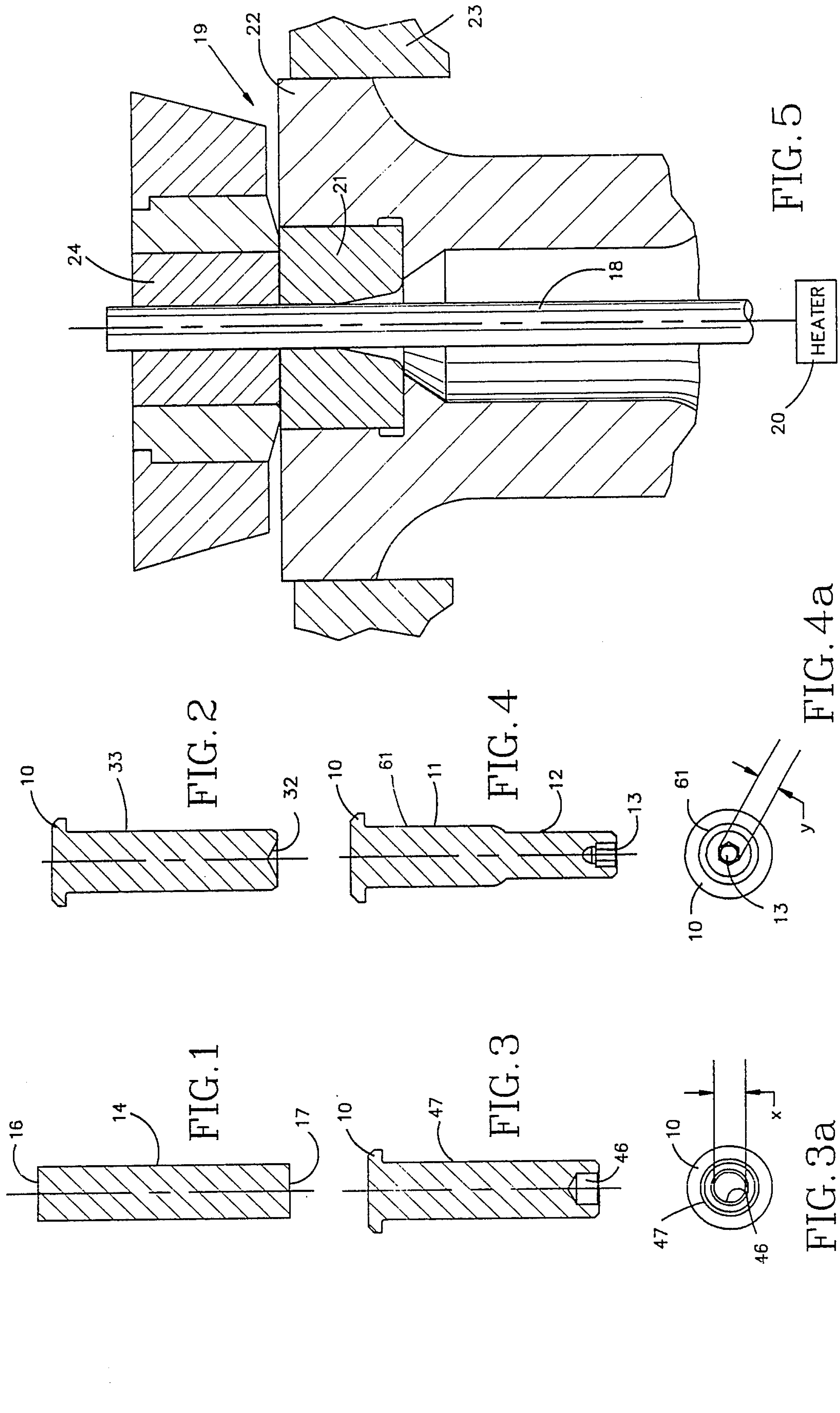


FIG. 5
19
22
23
21
24
18
HEATER
20
FIG. 2
10
33
32
FIG. 4
10
61
11
12
13
FIG. 4a
61
y
10
13
FIG. 1
16
14
17
FIG. 3
10
47
46
FIG. 3a
10
x
47
46

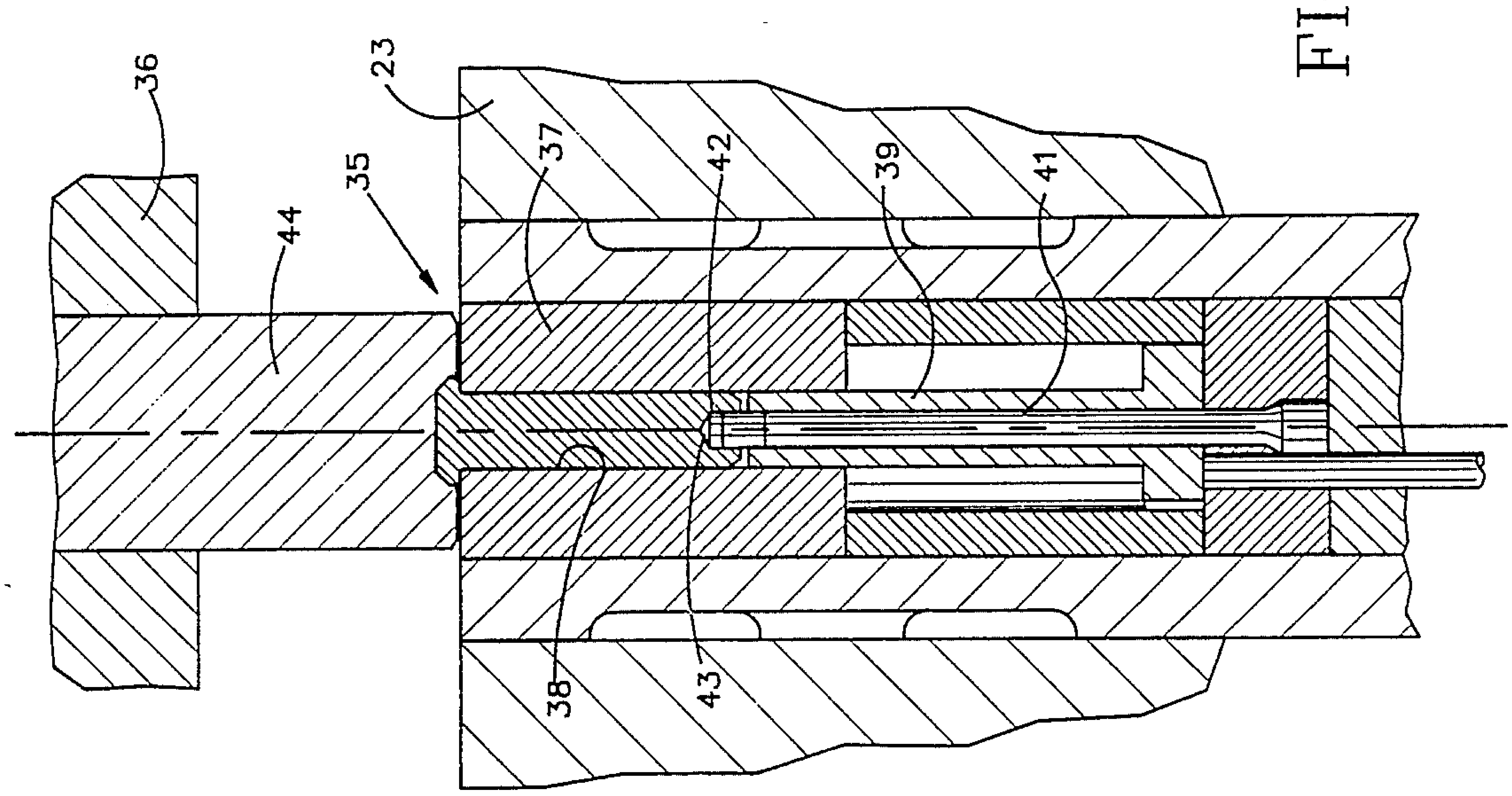


FIG. 7

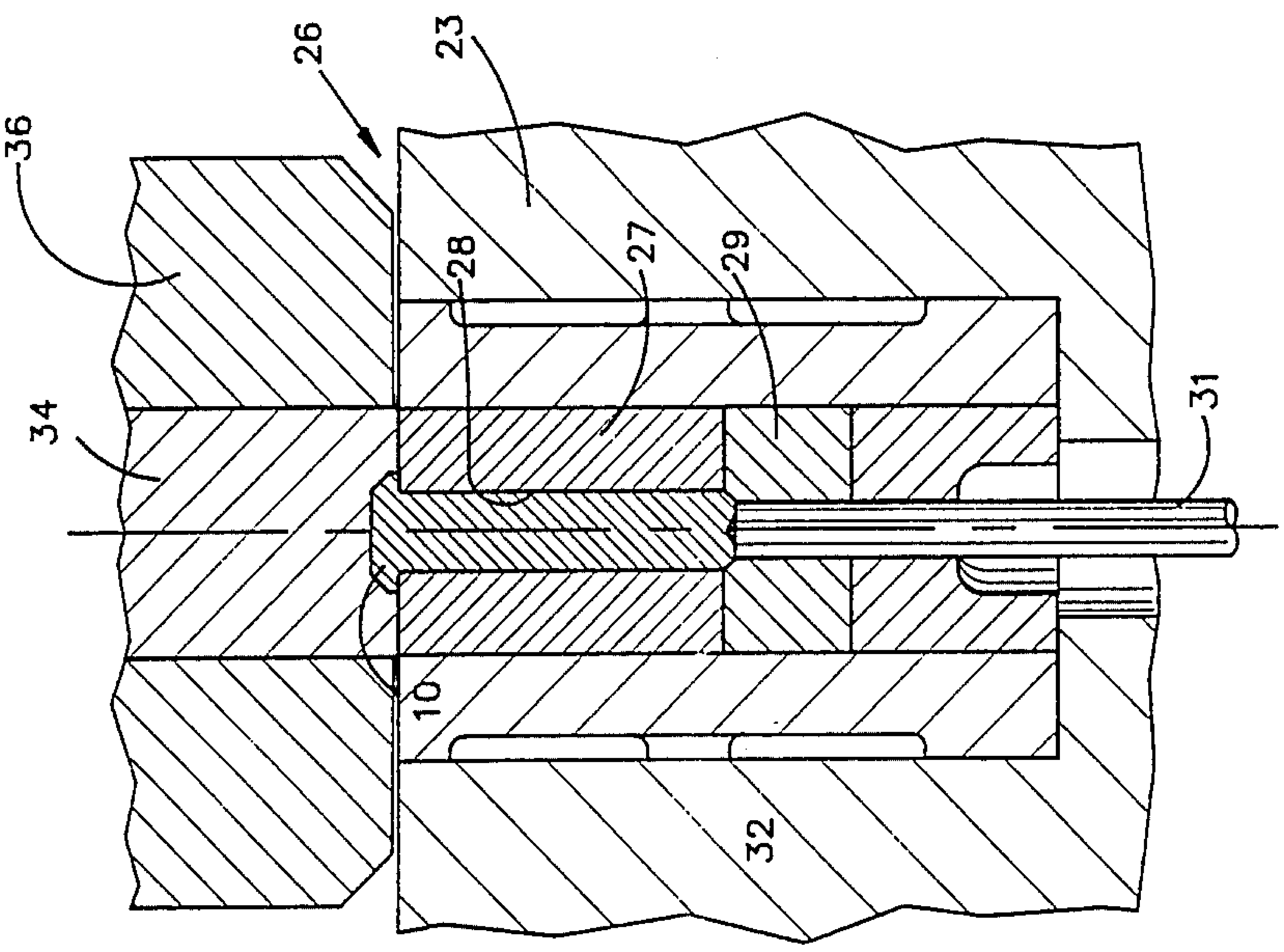


FIG. 6

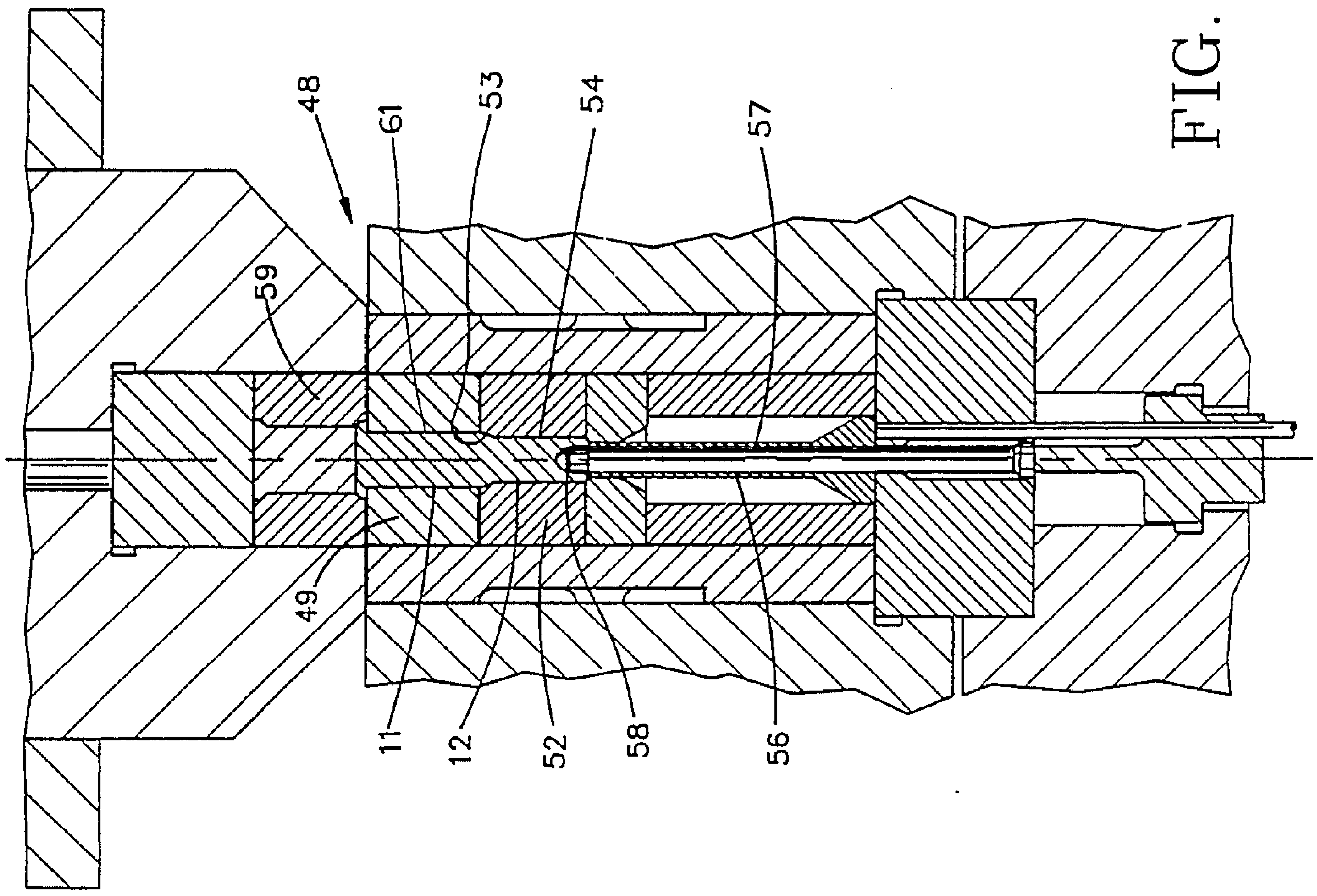


FIG. 9

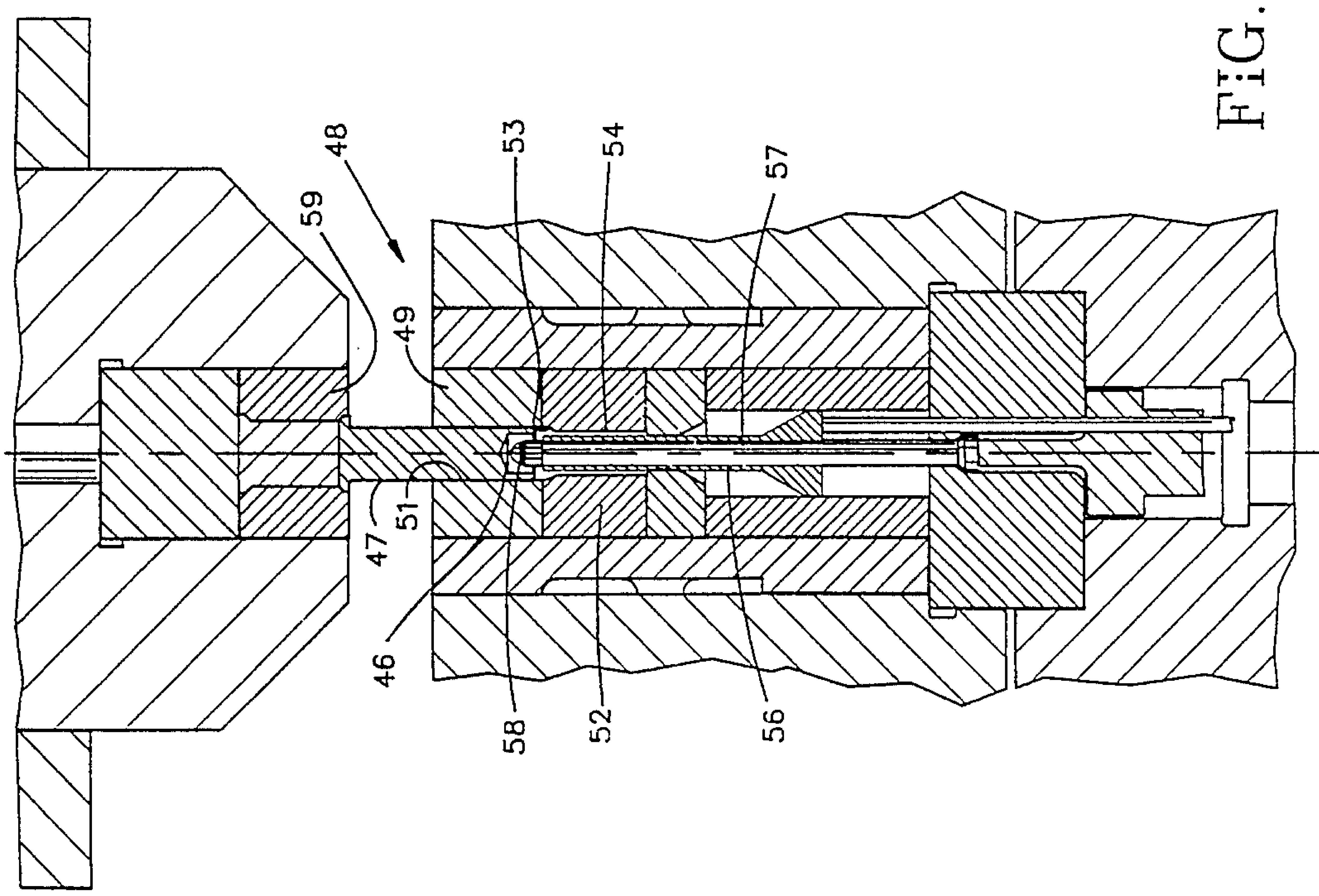


FIG. 8

METHOD AND APPARATUS FOR PRODUCING FASTENERS HAVING WRENCHING SOCKETS THEREIN

BACKGROUND OF THE INVENTION

This invention relates generally to the manufacture of fasteners, and more particularly to a novel and improved method and apparatus for producing fasteners having wrenching sockets, such as hexagonal sockets formed therein.

PRIOR ART

Socket head screws having non-circular wrenching openings therein are well known. In many instances, the opening or socket is formed with a hexagonal cross section sized to accept an Allen wrench or the like. Generally in the past, fasteners of such type were produced by pressing a hexagonal punch into the fastener blank, causing the material of the blank to flow and extrude back around the punch to produce the desired shape of wrenching socket. U.S. Pat. No. 1,978,371 discloses a typical example of such method of producing socket head cap screws.

It is also known to form socket head fasteners by upsetting the fastener blank material within a die, using a punch which forms a cylindrical opening in the head, and thereafter, in the same die, further upsetting the material of the head with a hexagonal punch to produce a hexagonal socket within the head of the fastener. Such process is illustrated and described in U.S. Pat. No. 3,182,342.

U.S. Pat. No. 3,457,573 also discloses a method of producing a hollow bolt having a hexagonal wrenching socket extending from one end thereof. In accordance with the method of such patent, a hexagonal mandrel is positioned within a tube and the material of the tube is deformed radially in against the surface of the mandrel and extruded along the length thereof to produce a bolt portion which provides a hexagonal inner surface for wrenching purposes and a cylindrical exterior surface.

The method of producing socket head cap screws illustrated in U.S. Pat. No. 1,978,371, supra, in which a hexagonal punch is driven into the material of the fastener to form a wrenching socket therein, has been extensively used. However, difficulties are encountered due to punch breakage or excessive wear if the material forming the fastener is difficult to forge. Further, the difficulty is accentuated when the socket must be quite small. For example, it has been virtually impossible to forge small wrenching sockets in titanium and in some highstrength steels on a production basis utilizing a noncircular punch to form the wrenching socket within the fastener.

SUMMARY OF THE INVENTION

The present invention provides a novel and improved method and apparatus for forming fasteners with wrenching sockets. With the present invention, very small wrenching sockets can be produced in materials which are difficult to form, such as titanium and high-strength steel, without encountering excessive tool wear or tool breakage.

In accordance with this invention, a preliminary socket having a circular cross section is formed in the material of the blank used to form the fastener. Subsequently, a finish tool having the shape of a required wrenching socket is positioned in the preliminary

socket and the material around the preliminary socket is deformed inwardly into mating engagement with the tool. Because the tool is not subjected to high forces required to flow the material and produce the socket, wear and tool breakage are minimized.

Further, because the punch which forms the initial socket does not have sharp edges, which tend to wear, the punch provides a good tool life.

In the preferred embodiment, the circular punch which forms the preliminary socket has a diameter equal to ore greater than the maximum lateral dimensions of the required finished socket. Therefore, the finish tool can be easily positioned within the preliminary socket without deforming the material of the blank. Consequently, the finish tool is not subjected to high forming loads.

Further, it is preferred to form the size of the preliminary socket so that the cross-sectional area of the blank material around the preliminary socket is slightly greater than the cross-sectional area of the material around the finished socket. Therefore, when the material is deformed inwardly against the finish tool, some lengthwise displacement must occur, ensuring that the material of the blank around the socket accurately takes the shape of the finish tool.

In the preferred and illustrated embodiment, the blank having the preliminary socket therein is axially pressed through an extrusion die which deforms the material of the blank inwardly into engagement with the finish tool.

In instances in which the fastener is manufactured from titanium, which is a material very difficult to deform by forging processes, the blank material is first heated and is formed by what is normally referred to as "warm forming". For example, the blank material is preferably at a temperature of about 1200° F. to 1400° F. when it is processed in accordance with the method of this invention.

With this invention, it is practical to forge articles which have been impractical to forge in the past.

These and other aspects of this invention are illustrated in the accompanying drawings, and are more fully described in following specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates the shape of an initial blank;

FIG. 2 illustrates the first intermediate blank after the first forming operation thereon;

FIG. 3 illustrates the second intermediate blank after the preliminary socket is formed in the end thereof;

FIG. 3*a* is an end view of the blank illustrated in FIG. 3;

FIG. 4 illustrates the finished blank after the wrenching socket is completed;

FIG. 4a is an end view of the blank illustrated in FIG. 4;

FIG. 5 is a longitudinal section of the shearing station in which the blanks of FIG. 1 are cut from rod or wire stock;

FIG. 6 is a longitudinal section illustrating the tooling at a first work station in which a head is formed to produce the first intermediate blank of FIG. 2;

FIG. 7 is a longitudinal section illustrating the tooling at a second work station in which a preliminary socket in the end of the blank produces the second intermediate blank of FIG. 3;

FIG. **8** is a longitudinal section of the tooling at a third work station illustrating the various tooling components in the position in which the finish tool is positioned within the preliminary socket but before the blank is extruded; and

FIG. **9** is a cross section similar to FIG. **8** but illustrating the position of the tooling and the finished workpiece at the completion of the last operation.

DETAILED DESCRIPTION OF THE DRAWINGS

The fastener which is produced in the illustrated embodiment of this invention is a fastener known in industry as a "HI-LOK fastener." Such fasteners are used extensively in the aircraft industry and are illustrated in U.S. Pat. Nos. 3,138,987 and 3,390,906. Such patents are incorporated by reference.

Prior to the present invention, it has been virtually impossible to produce such a fastener by forging processes when the material of the fastener was titanium.

The finished blank illustrated in FIG. **4** provides a head **10**, a shank **11** of the first diameter, and a reduced diameter extension **12** extending from the end of the shank **11** remote from the head **10**. A hexagonal socket **13** is formed in the end of the extension **12** and is sized to receive a hexagonal wrench. The finished blank of FIG. **4** is subsequently roll-threaded along the reduced diameter portion **12**.

FIG. **1** illustrates the initial blank used to form the fastener illustrated in FIG. **4** in accordance with the present invention. The initial blank **14** has a cylindrical shape and relatively square and flat ends **16** and **17**. Such blank **14** is normally sheared from wire or rod stock, as illustrated in FIG. **5**.

The tooling of the present invention is mounted on a transfer former or forging machine of the general type illustrated and described in U.S. Pat. No. 3,247,534, and such patent is incorporated herein by reference to illustrate the overall structure of such machines.

As illustrated in FIG. **5**, rod stock **18** is longitudinally fed into a shear station **19** of a progressive former through a heater schematically illustrated at **20**. At the shear station, a cutting die **21** is mounted within tooling **22**, which is in turn supported on the frame **23** of the progressive former. The stock **18** projects through a cutter tube **24**, which is movable along the face of the cutting die **21** and operates to shear the blank **14** from the stock. Subsequently, the blank is ejected into an automatic transfer (not illustrated) which transports the blank **14** to a first work station **26**, illustrated in FIG. **6**. At the first work station, a die set is mounted in the machine frame and provides a forward die **27** having a uniform diameter die cavity **28** formed therein. Rearwardly of the forward die **27** is a backup die **29** and a kickout pin **31**. The end face of the kickout pin is shaped to form a shallow, conical recess **32** (best illustrated in FIG. **2**) in the end of the first intermediate blank **33**.

An upsetting tool **34** is carried by the slide assembly **36** of the forming machine. The slide is reciprocable back and forth between a forward position and a retracted position in the usual manner. As the slide carries the tool to its forward position illustrated in FIG. **6**, the tool **34** upsets a head **10** on the end of the blank **14** projecting out of the die **27** and the shallow recess **32** is formed at the inner end of the blank.

After the first intermediate blank **33** is formed at the work station **26**, the blank **33** is ejected by the kickout pin into a transfer which transfers the intermediate blank to a second work station **35** illustrated in FIG. **7**. At this work station, a tubular die **37** having a cylindrical die cavity **38** is again mounted in the machine frame **23**. Projecting into the die cavity **38** is a stripper sleeve **39** through which a preliminary punch **41** projects. The forward end of the punch is provided with a cylindrical land **42** and a shallow conical end face **43**.

Also located at the second work station **35** is a tool **44** carried by the slide assembly **36** which presses the first intermediate blank **33** down along the die **37** and over the end of the preliminary punch **41** to form a preliminary socket **46** in the end of a socket intermediate blank **47**, as best illustrated in FIG. **3**. In such operation, the head **10** formed in the previous work station remains unchanged.

After the forming operation occurring in the second work station **35** is completed, the stripper sleeve **39** is advanced to eject the second intermediate blank **47** from the die **37** and the transfer operates to position the blank at a third work station **48**, illustrated in FIGS. **8** and **9**. Located at the third work station **48** is a set of dies including an outer, tubular die **49** having a cylindrical die cavity **51** therein sized to closely fit the periphery of the cylindrical portion of the second intermediate blank **47**. Inwardly from the outer die **49** is an inner die **52** having a conical extrusion throat **53** from which a cylindrical die cavity **54** extends. The diameter of the die cavity **54** is approximately equal to the diameter of the extension **12** of the finished blank.

Extending along the die cavity **54** is a stripper sleeve **56** through which a finish tool **57** extends. The finish tool is formed with an end having the shape of the required wrenching socket **13**, and in the illustrated embodiment is a hexagon in cross section. Both the stripper sleeve **56** and the finish tool **57** are slidable in the die cavities and, at the commencement of the working operation occurring at the third work station, the hexagonal end **58** is positioned forwardly within the dies and is located within the preliminary cylindrical socket **46** of the blank as the blank moves in along the outer die cavity **51**.

Here again, tooling **59** is mounted on the slide assembly **19** and engages the head **10** of the second intermediate blank **47** as it moves toward its full forward position. The completion of the working operation, is illustrated in FIG. **9**. Initially, the blank moves along the outer die cavity **51**, with the hexagonal end **58** of the finish tool **57** positioned within the preliminary socket **46**, until the inner end of the second intermediate blank **47** reaches the extrusion throat **53**.

As the tooling **59** continues toward the die **49**, the forward end of the blank is pressed through the extrusion throat **53** and is deformed radially inward against the hexagonal end **58** of the finish tool. The hexagonal end and the extrusion die are sized so that the material forming the end of the intermediate blank is pressed into tight mating engagement with the hexagonal end to form the finished hexagonal socket **13** of the finished fastener blank **61** illustrated in FIG. **4**. Further, as the blank is carried forward, the blank material is extruded to reduce the diameter of the extension **12**, completing the manufacture of the fastener. Subsequently, the threads are rolled onto the reduced diameter extension **12** to complete the fastener.

It is preferable to size the preliminary socket **46** so that the cross-sectional area of the material of the second intermediate blank **47** surrounding the preliminary socket **46** is slightly greater than the cross-sectional area of the material of the finished blank **61** surrounding the hexagonal wrenching socket **13**, so that a limited amount of extrusion occurs around the hexagonal end. This ensures that intimate contact is established between the surface of the hexagonal wrenching socket and the hexagonal end **58** of the punch. Therefore, the depth of the socket **13** tends to exceed the depth of the cylindrical portion of the preliminary socket **46** a small amount.

Further, it is preferable to size the preliminary punch so that the preliminary socket **46** has a diameter, indicated at X in FIG. *3a*, which is at least as greater as the across-corners dimension Y, illustrated in FIG. *4a*, of the hexagonal socket. With such a dimensional relationship, the hexagonal end **58** enters the preliminary socket **46** without requiring any deformation of the material of the blank. In fact, it is preferable to form the diameter of the preliminary socket **46** larger than the maximum lateral dimension of the wrenching socket **13**, so that the end of the punch has the maximum strength possible consistent with the size requirements of the finished fastener.

In the particular illustrated embodiment the outside diameter of the second intermediate blank is about 0.223 inch, and the preliminary socket has a diameter of about 0.108 inch. Further, the preliminary socket has a depth of the cylindrical portion thereof of about 0.085 inch. After the extrusion operation, the reduced diameter extension **12** has a diameter of about 0.174 inch. Across the flats of the hexagonal socket, the finished socket **13** has a lateral dimension of about 0.079 inch and a depth of about 0.090 inch.

With the present method, very small hex sockets can be successfully produced in production by forging even in hard-to-form material such as titanium or high-strength steel without excessive wear of the tooling. For example, a finished tool having the dimensions mentioned above successfully functioned to produce over 90,000 titanium parts without encountering any measurable wear or damage. Further, because the preliminary socket was formed of a somewhat larger diameter cylindrical punch, the preliminary punch did not experience excessive wear, even when forming titanium.

In the processing of titanium fasteners as illustrated, the blank material was heated to about 1400° F. to increase its plasticity prior to being formed into the finished blank. However, satisfactory tool life can be obtained in materials which are more easily forged when the forging operations are conducted at room temperature.

Although the preferred embodiment of this invention has been shown and described, it should be understood that various modifications and rearrangements of the parts may be resorted to without departing from the scope of the invention as disclosed and claimed herein.

What is claimed is:

1. A forging machine for producing elongated articles having a non-circular socket extending along said article from one end thereof from an elongated blank having a uniform cross section, comprising a frame, a slide reciprocable on said frame, said machine providing at least two work stations, tooling supported by said frame and slide at each of said work stations, said tooling at one of said work stations including a die having a die cavity extending from an entrance end and sized to closely fit the exterior of one end of said blank, and a first punch within said die cavity having a cylindrical end extending toward and spaced back from said entrance end, said tooling at said one work station also including tool means operable to engage the other end of said blank and move said one end of said blank along said die cavity and over said punch to form a cylindrical socket in said one end without increasing the size of said one end, said tooling at the other of said work stations including a second die having a second die cavity extending from an entrance end to an extrusion throat spaced from said entrance end, and a second punch having a non-circular end sized to fit into said cylindrical socket without substantial interference, said extrusion throat and non-circular end of said second punch being relatively movable from a first portion in which said non-circular end projects through said extrusion throat toward said entrance end of said second die and a second position in which said non-circular end is on the side of said extrusion die remote from said entrance end of said second die, said tooling at said other work station also including a second tool means operable to apply an axial force to said other end of said blank causing said one end of said blank to engage said extrusion throat and pass therethrough while said non-circular end of said second punch is positioned in said cylindrical socket to laterally deform the material of said blank against said non-circular end forming said non-circular socket without applying substantial longitudinal forces to said second punch.

2. A machine as set forth in claim **1**, in combination with a heater for preheating said blank.

3. A forging machine for producing elongated articles having a non-circular socket extending in along said article from one end thereof from an elongated blank having a uniform cross section, comprising a frame, a slide reciprocable on said frame, said machine providing at least two work stations, tooling supported by said frame and slide at each of said work stations, said tooling at one of said work stations including a cylindrical first punch and means for pressing said blank onto said first punch, operable to press into said blank from one end to form a cylindrical socket in said blank extending into said one end, said tooling at the other of said work stations including a second punch having a non-circular end sized to fit into said cylindrical socket without substantial interference and an extrusion throat about said non-circular end and sized to reduce the size of said blank around said cylindrical socket, said tooling at said other work station also including tool means operable to engage the other end of said blank and apply a force thereto to move said one end into and through said extrusion throat while said second punch non-circular end is in said cylindrical socket causing the material of said blank around said cylindrical socket to deform inwardly into engagement with said non-circular end of said second punch to form said non-circular socket without exerting substantial longitudinal forces on said second punch.

4. A forging machine as set forth in claim **3**, wherein said non-circular end is hexagonal.

5. A forging machine as set forth in claim **4**, wherein said extrusion throat operates to reduce the cross-sectional area of the blank around said cylindrical socket.

6. A forging machine as set forth in claim **5**, wherein said machine provides a third work station having tooling supported on said frame and slide operable to form a head on the other end of said blank.

7. A forging machine as set forth in claim **5** in combination with a heater for preheating said blank.

8. A method of forming metal elongated articles having a non-circular socket extending into one end, comprising pressing a circular punch into one end of a blank to form a cylindrical socket in said one end thereof, positioning a noncircular punch in said cylindrical socket, and while said noncircular punch is so positioned pressing said one end of said blank through an extrusion throat by a force applied to the other end of said blank to displace the material of said blank around said cylindrical socket into engagement with said non-circular punch to form said cylindrical socket into a non-cylindrical socket without applying substantially longitudinal forces to said non-circular punch.

9. A method as set forth in claim 8, including applying lateral pressure to produce a cylindrical periphery around said non-circular socket during said pressing step.

10. A method as set forth in claim 8, including sizing said blank and said cylindrical socket so that the cross-sectional area of the material of said blank surrounding said cylindrical socket is larger than the cross-sectional area of the material of said blank surrounding said non-circular socket to ensure intimate engagement between said blank material and said non-circular punch.

11. A method as set forth in claim 8, including providing said blank with an initial diameter and during said pressing step extruding a portion of said blank at said one end to a cylindrical shape having a diameter less than said initial diameter of said blank.

12. A method as set forth in claim 11, including upsetting a head on the other blank.

13. A method as set forth in claim 12, including forming said article from a titanium blank.

14. A method as set forth in claim 13, including forming said non-circular socket with a hexagonal cross section having an across-the-flats dimension less than 0.1 inch, and preheating said blank to increase the plasticity thereof.

15. A method as set forth in claim 14, including preheating said blank to at least about 1200° F.

16. A method of forming titanium "HI-LOK" fasteners from a cylindrical blank comprising upsetting a head on one end of said blank, pressing the other end of said blank over a cylindrical tool to form a cylindrical socket therein, positioning a second tool having a hexagonal end in said cylindrical socket, and while said hexagonal end remains in said cylindrical socket applying a force to said one end of said blank for pressing said other end through an extrusion die and forming said other end into engagement with said hexagonal end to produce a hexagonal socket therein without applying substantial longitudinal forces to said second tool.

17. A method as set forth in claim 16, including preheating said blank to a temperature of about 1200° F. to 1400° F.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,805,437

DATED : Feb. 21, 1989

INVENTOR(S) : Nicholas A. Heil, Jr., et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Under references cited, fifth reference, "1939" should be --1938--.

Col. 1, line 52 "highstrength" should be --high-strength--.

Col. 2, line 11 "ore" should be --or--.

Col. 2, lines 11 and 12 "dimensions" should be --dimension--.

Col. 4, line 12 "socket" (second occurrence) should be --second--.

Col. 5, line 12 "greater" should be --great--.

Col. 6, line 40 after "punch," should be inserted --said first punch--.

Signed and Sealed this

Twenty-ninth Day of August, 1989

Attest:

DONALD J. QUIGG

Attesting Officer *Commissioner of Patents and Trademarks*